Distributed Generation Improvements in Industrial Applications

CHP Integration with Fluid Heating Processes in the Chemical and Refining Sectors

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CHP Integration with Fluid Heating in Chemical and Refining Sectors

- Links to DER Strategy
  - Encourage CHP in Industry (Chemical and Refining)
  - Incremental Fluid Heating CHP Applications Could Double the CHP Potential from Traditional Steam Systems
  - Environmental and Efficiency Benefits

Impact to CHP Opportunity in Chemical and Refining Sectors

- Based on Selected Chemicals and Refining Processes
- 22 GW of Remaining New Steam CHP Potential
- 40 GW of New Fluid Heating CHP Potential

- 62 GW of Total New CHP Potential

- (7 GW of Existing CHP Capacity in Selected SICs)

CHP Integration with Fluid Heating in Chemical and Refining Sectors

- Objectives
  - Estimate the MW Potential of a Larger CHP Market as Compared to Traditional Steam CHP
  - Evaluate Technical Issues Including Temperature Requirements and Process Integration
  - Industrial Survey to Augment Field Findings
  - Recommendations to Overcome Economic and Technical Hurdles

Scope of Work

PROGRESS

Completed

- **Task 1: Market Assessment**
  - Identify SICs with fluid heating processes, equipment types, temperatures
  - Estimate MW potential, develop economic criteria for U.S.
- **Task 2: Technical Feasibility**
  - Detailed evaluation of two fluid heating applications (ethylene plant and refinery)
  - Investigate issues affecting feasibility of CHP integration (economic & environmental)
- **Task 3: Industrial Survey**
  - Discussion Paper
  - Perform Industrial Survey
  - Recommendations

Completed

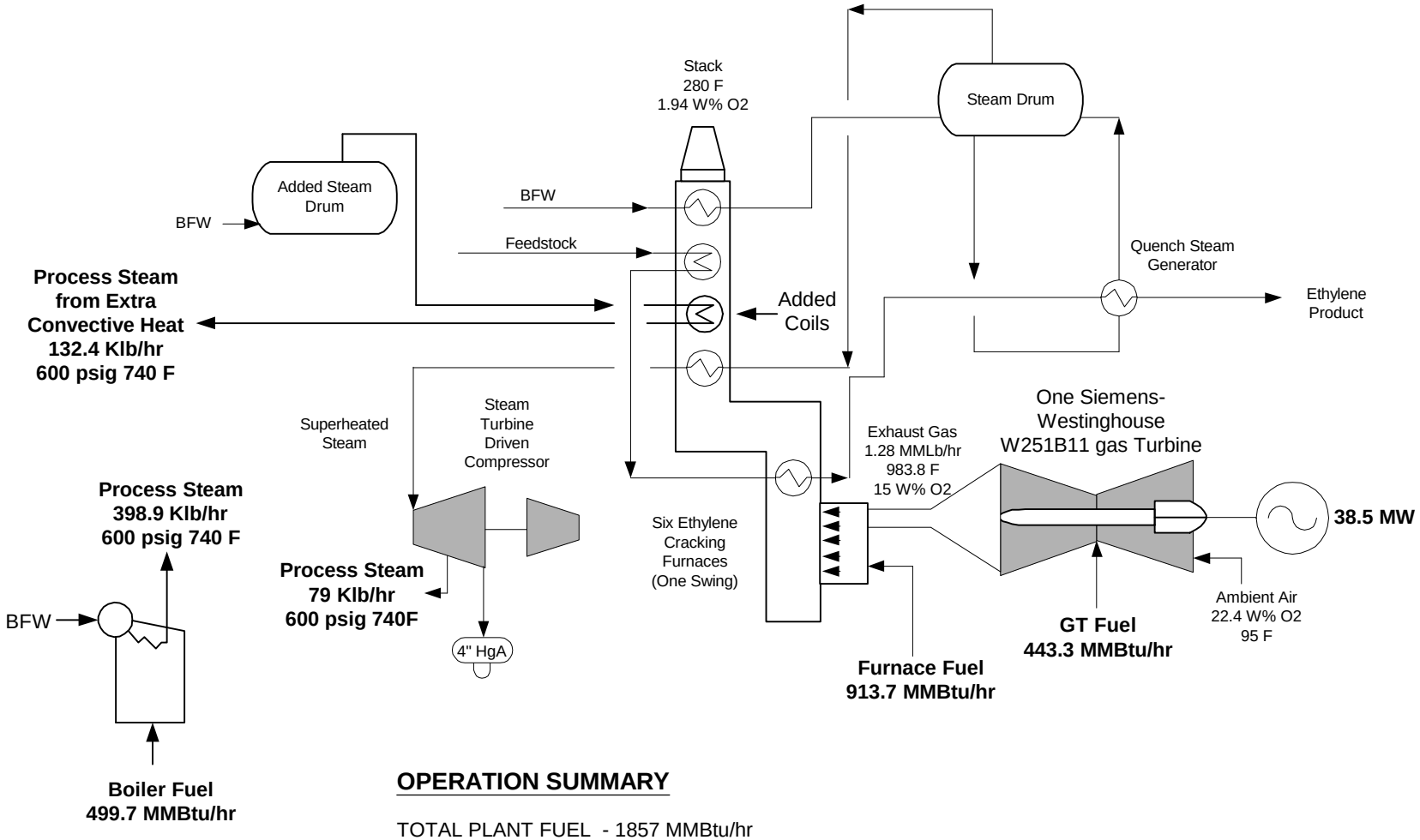
- **Task 4: Final Report**

(awaiting final comments)

Types of Fluid Heating CHP

- **Radiant GTI** (e.g. ethylene plant example)
  - Gas turbine exhaust used as combustion air to furnace
  - Can be integrated with all process temperature requirements
  - Supplemental burners used
  - Design sensitive to exhaust O_2 content and temperature
  - Gas turbines with lower inlet temperatures with higher O_2 preferred
  - Single shaft turbines exhibit favorable thermal inertia characteristics in the case of an emergency shut-down
  - Our analysis showed a cogenerative efficiency of 75.9% for GTI as compared to 65.6% and 62.8% for cogenerative simple cycle and combined cycles

Example of Radiant GTI (Ethylene Plant)



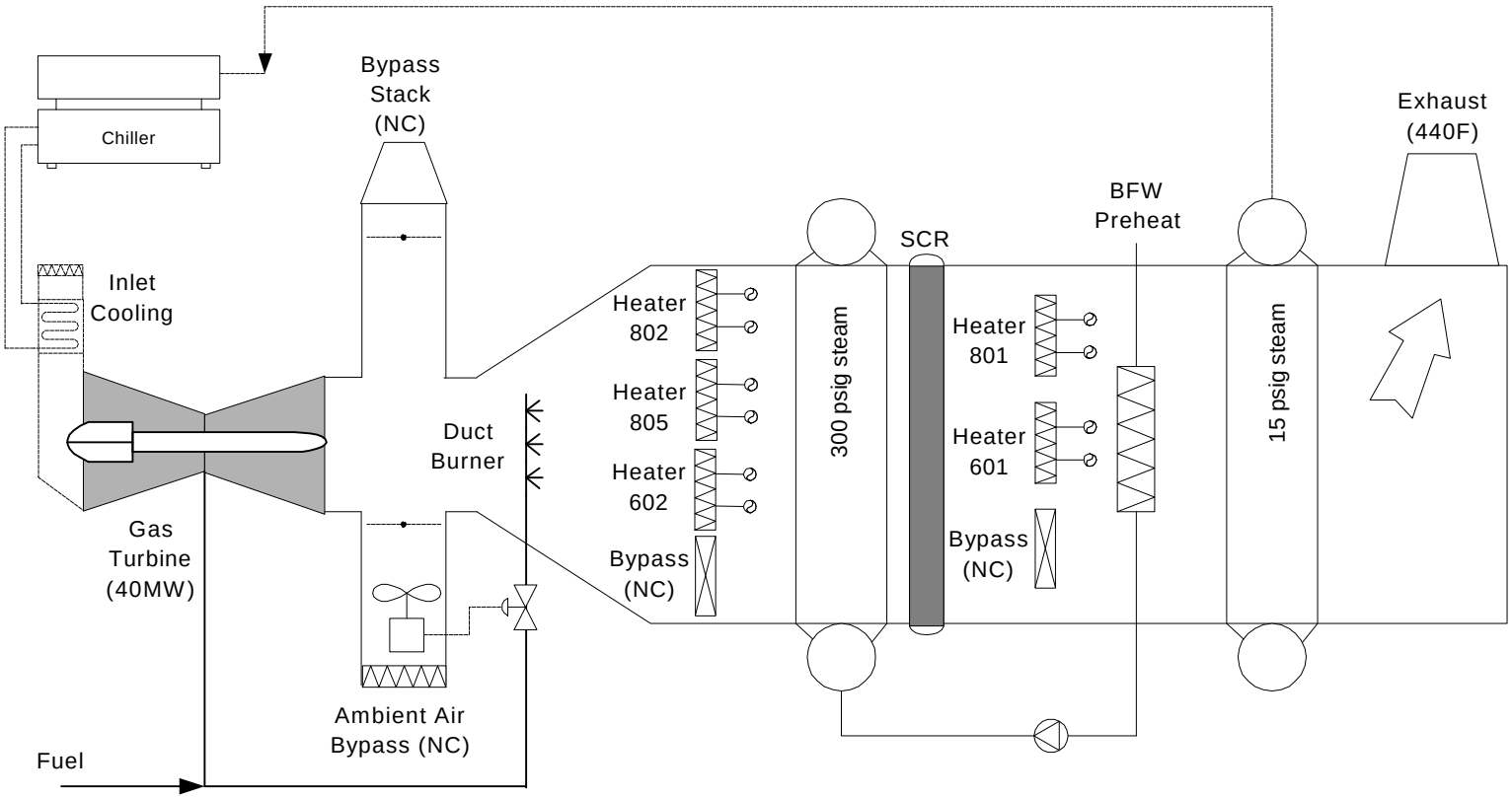
OPERATION SUMMARY

TOTAL PLANT FUEL - 1857 MMBtu/hr
GENERATED POWER - 38.5 MW
PURCHASED POWER- 34.4 MW
TOTAL PROCESS STEAM - 610.3 Klb/hr
FUEL CHARGEABLE TO POWER (FCP) - 4497 Btu/kWh
COGENERATIVE EFFICIENCY - 75.9 %

Types of Fluid Heating CHP

- **Convective GTI** (e.g. crude oil heaters in a refinery)
  - Gas turbine exhaust is directed to a waste heat exchanger
  - Well suited to convection heat transfer applications (no-high temperature radiant duty)
  - Not suitable for processes with high-temp endothermic “cracking” chemical reactions
  - Fluid heating and steam generation can be accomplished in a single waste heat exchanger

Example of Convective GTI (Refinery)



Fluid Heating Processes

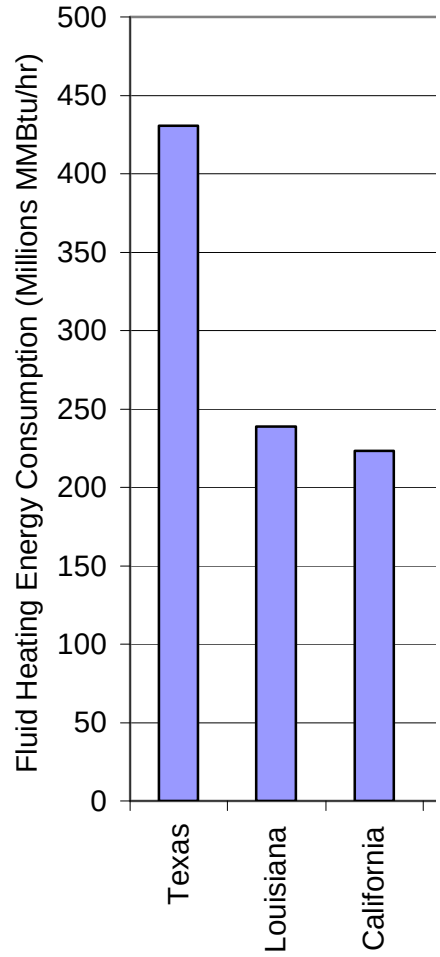
	Fluid Heating CHP (GW)	
Refining Processes	**Convective**	**Radiant**
Distillation		
Atmospheric	11.0	2.5
Vacuum	3.3	0.7
Coking	3.6	0.8
Catalytic Processes		
Fluid Cracking	3.2	0.7
Reforming	8.3	1.9
Hydrocracking	1.5	0.4
Hydrotreating	5.5	1.3
Total	**36.4**	**8.3**

	Fluid Heating CHP (GW)	
Chemical Processes	**Radiant**	**Convective**
Ethylene	2.7	*
Ammonia	1.0	*
Carbon Black	0.3	*
Methanol	0.3	*
Urea	0.1	0.6
Styrene	0.2	*
Vinyl Chloride	0.1	0.5
Benzene, Toulene, Xylenes	0.1	0.4
Soda Ash	0.04	0.2
Propylene Oxide	0.04	0.2
Caprolactam	0.03	0.1
Acrylonitrile	0.01	0.03
Total	**5.0**	**2.1**

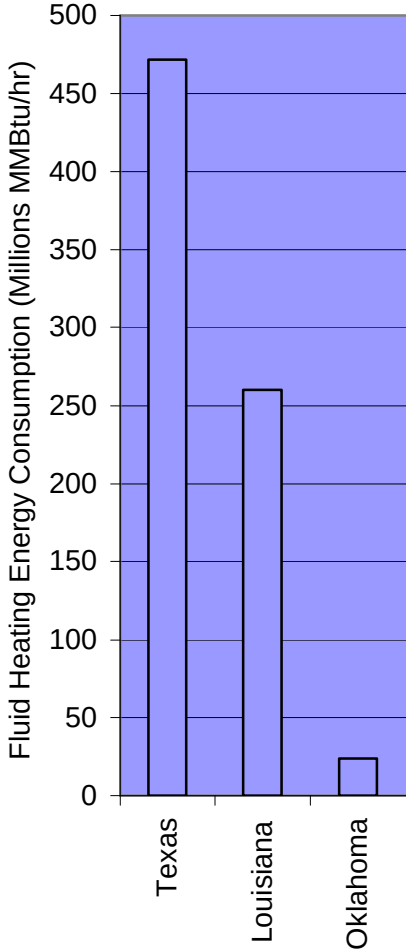
* High temperature processes above 1000F that require a radiant GTI approach

Target Markets (Top States)

Refining



Chemicals



Industry Survey Opinions

- Participants
  - Plant operators, equipment vendors, engineering firms
- Major Issues
  - Environmental compliance (NOx) when supplementary fired
  - Regulatory blocks to full competition – electric utility interference
  - Technical – process control and oxygen deprivation
  - Low cost of energy/feedstock has hindered CHP development
  - Scare capital resources
  - Steam systems are less risky than fluid heating CHP applications – not tied directly to process

Recommendations for Future Work

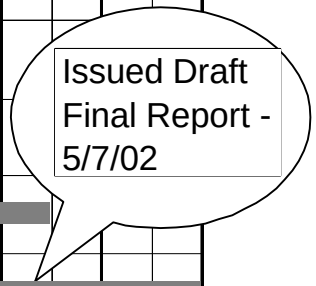
- Additional analysis of GTI – cost estimates and heat balances as a function of firebox temperature and different gas turbine models
- GTI demonstration project
- Evaluate fluid heating integration with solid oxide and molten carbonate fuel cells
- Investigate emission control technology
- Organize a stakeholder workshop to facilitate implementation
- Investigate other opportunities in other sectors and applications – glass, metals, cement, drying, heat treating

Progress to Date

	Progress Report Submitted
Task 1: Fluid Heating Market	
• Identify SICs with Fluid Heating (Task 1.1)	✓
• Database Screening (Task 1.1)	✓
• Economic Criteria (Task 1.2)	✓
• Target Markets (Task 1.3)	✓
Task 2: Site Evaluation	
• Performed Refinery Site Visit (Task 2.1)	✓
• Performed Technical Assessment (Task 2.1)	✓
• Economic and Environmental Assessment (Task 2.2)	✓
• Recommendations (Task 2.3)	✓
Task 3: Industrial Survey	
• Discussion Paper (Task 3.1)	✓
• Perform Industrial Survey (Task 3.2)	✓
• Recommendations (Task 3.3)	✓
Task 4: Final Report	✓

Schedule

	Description	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02
TASK 1	FLUID HEATING CHP MARKET												
TASK 2	SITE EVALUATION OF FLUID HEATING CHP												
TASK 3	INDUSTRIAL SURVEY												
TASK 4	FINAL REPORT												



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